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18 January 2000

Assistant Commissioner for Patents
Washington, D.C. 20231

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Attorney Docket: P55955

Sir:

Submitted herewith is the following patent application:

Inventor: **1) KEUN-HO SHIN**

Title: **OPTICAL FILTER AND APPARATUS AND METHOD FOR MONITORING OPTICAL CHANNEL USING THE OPTICAL FILTER**

Please find attached hereto an application for patent which includes: Specification and Abstract, Claims, original Declaration And Power of Attorney, Assignment, and a certified copy of the foreign priority document identified below:

Verified Showing of Small Entity Status: **NO**

Drawings: Formal drawings, 1 sheet, Figures 1 through 3

Claim of priority under 35 U.S.C. §119: **YES**

** The Republic Of Korea Application No. 1260/1999 filed on 18 January 1999.

FEE (see formula below): **CHECK IS ENCLOSED (#34526)**

Basic Fee $345/690	$690.00
Additional Fees:	
Total number of claims in excess of 20: ___ times $9/18 .	$0.00
Number of independent claims in excess of 3: ___ times $39/78	$0.00
Multiple Dependent Claims $130/260	$0.00
An Assignment is likewise enclosed: Recording Fee $40 . .	$0.00
Filing Non-English specification	$0.00
TOTAL FEES FOR THE ABOVE APPLICATION	***$690.00***

Inventor: 1) KEUN-HO SHIN

Title: OPTICAL FILTER AND APPARATUS AND METHOD FOR MONITORING OPTICAL CHANNEL USING THE OPTICAL FILTER

Assistant Commissioner is authorized to charge our Deposit Account No. 02-4943 for any additional charges necessary towards payment of the issue fee for the above-referenced application. Please notify the undersigned attorney of any transaction regarding our Deposit Account.

In view of the above, it is requested that this application be accorded a filing date pursuant to 37 CFR 1.53(b).

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Respectfully submitted,

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TITLE OF THE INVENTION

OPTICAL FILTER AND APPARATUS AND METHOD FOR MONITORING OPTICAL CHANNEL USING THE OPTICAL FILTER

CLAIM OF PRIORITY

This application makes reference to, incorporates the same herein, and claims all benefits accruing under 35 U.S.C. §119 from an application entitled *Optical Filter And Apparatus And Method For Monitoring Optical Channel Using The Optical Fiber* earlier filed in the Korean Industrial Property Office on the 18th day of January 1999, and there duly assigned Serial No. 1260/1999 by that Office.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a wavelength division multiplexing (WDM) optical communications system, and more particularly, to an apparatus and method for analyzing the spectrum of an optical signal using etalon to monitor a change in the wavelength of a wavelength division multiplexed (WDM) optical signal and the optical signal-to-noise ratio (OSNR) of the WDM optical signal.

Description of the Related Art

Monitoring of WDM optical signals in optical transmission systems is a key technique in wavelength division multiplexing (WDM). The monitoring of an optical signal of each channel as to whether the optical signals operate normally is required to obtain high reliability in optical transmission systems.

Measuring the OSNR of each channel, a change in the wavelength, and the number of wavelengths, which is essential for channel monitoring techniques, is performed by obtaining amplified spontaneous emission (ASE), and the output and wavelength in each channel.

In the prior art, a method of transmitting a dither signal to each channel, a method of using an arrayed waveguide grating (AWG) or a tunable filter which are optical devices, and other commercialized spectrum analyzer techniques are applied to achieve the above measurement.

Precise measurement of a peak value in a wavelength and the OSNR is essential for wavelength monitoring. However, the method of transmitting a dither signal to each channel and monitoring an optical signal in a receiving terminal using a phase locked loop (PLL) cannot obtain a wavelength value. The method using optical devices such as an AWG, a tunable filter, or the like, which can obtain even wavelength values, is quite costly. An optical spectrum analyzer or a multiple wavelength meter, which are used for optical spectrum analysis, is commercialized but expensive, so it is not suitable for channel monitoring. Therefore, there is an increasing demand for a spectrum analyzer which is simple and can be applied to monitor the channels of a WDM optical signal.

A spectrum analysis technique is the fundamental principle for achieving channel monitoring

of a WDM optical signal. In existing spectrum analysis techniques using a Fabry Perot tunable filter, the thickness of etalon is varied by an electrical signal, thus deteriorating the accuracy and requiring a controller for variable control.

U.S. Patent No. 5,825,792 for a *Wavelength Monitoring and Control Assembly for WDM Optical Transmission Systems* to Villeneuve et al discloses a Fabry-Perot etalon structure that provides feedback loop back to the laser source to control the laser source. What is needed is the use of such an etalon structure that interacts with the output of a fiber optic multiplexed signal to discern the spectral components and the optical signal to noise ratio of various wavelengths that may be traveling through an optical fiber.

SUMMARY OF THE INVENTION

An objective of the present invention is to provide an optical filter which effectively uses the function of etalon, and an apparatus and method for monitoring optical channels using the optical filter, in monitoring a channel signal of a wavelength division multiplexed (WDM) optical signal.

It is another object to discern the optical components of a WDM signal and discern the optical signal to noise ratio of each component.

To achieve the above objective of the invention, there is provided an optical filter including: an input unit for receiving a wavelength division multiplexed (WDM) optical signal via an optical transmission medium and outputting optical signals that have different incidence angles according to the wavelengths of the optical signals; and a filter for receiving the optical signals from the input

unit and separating the WDM optical signal into optical signals having different wavelengths using the difference between resonance lengths according to the different incidence angles.

To achieve the above objective of the invention, there is provided an optical channel monitoring apparatus including: an optical filter for receiving a WDM optical signal from an optical transmission medium, making the incidence angle of each wavelength of the WDM optical signal different from each other, and separating the WDM optical signal into optical signals having different wavelengths using the difference between resonance lengths according to the different incidence angles; and a detector for detecting the intensity of each of the optical signals having different wavelengths as an electrical signal.

To achieve the above objective of the invention, there is provided an optical channel monitoring method including: receiving a WDM optical signal from an optical transmission medium and outputting optical signals that have different incidence angles according to the wavelengths of the optical signals; receiving the optical signals and separating the WDM optical signal into optical signals having different wavelengths using the difference between resonance lengths according to the different incidence angles; and detecting the intensity of each of the optical signals having different wavelengths as an electrical signal.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention, and many of the attendant advantages thereof, will be readily apparent as the same becomes better understood by reference to the following

detailed description when considered in conjunction with the accompanying drawings in which like reference symbols indicate the same or similar components, wherein:

FIG. 1 illustrates the principle of a Fabry-Perot resonator;

FIG. 2 is a block diagram of an optical channel monitoring apparatus according to an embodiment of the present invention; and

FIG. 3 is a detailed diagram of FIG. 2.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, which illustrates the principle of a Fabry-Perot resonator which is a component of the present invention, an optical signal having a wavelength of λ is resonated in an etalon and transmitted through the etalon. The optical signal satisfies Equation 1:

EQUATION 1

$$\sin(2\pi L/\lambda) = m\pi \quad \ldots\ldots\ldots\ldots \quad (1)$$

wherein m is a positive integer, that is, 1, 2, 3, ... , and L denotes the interval between etalon plates.

In FIG. 1, when optical signals having wavelengths of λ_1 and λ_2 are incident upon the etalon via an optical fiber at different angles, they are transmitted at different angles. The present invention is a spectrum analysis technique using this principle. The principle is based on the fact that the resonance length between two mirrors depends on the incidence angle of light. When a wavelength

perpendicularly applied and transmitted is set to be λ_1, a predetermined number of wavelengths exist within a resonance length, so that the relationship shown in Equation 2 is established. When light is incident at an angle of θ, the resonance length is increased by Equation 3, and the transmission wavelength λ_2 of an optical signal is given by Equation 4.

EQUATION 2

$$\lambda_1 = \frac{L}{n} \qquad (2)$$

wherein n denotes the number of wavelengths within a resonator.

EQUATION 3

$$resonancelength = \frac{L}{\sin\theta} \qquad (3)$$

EQUATION 4

$$\lambda_2 = \frac{L}{n\sin\theta} \qquad (4)$$

The angle of detection depending on a wavelength which is used in WDM optical transmission systems, can be obtained using Equation 4, as shown in the following Table 1.

Wavelength (nm)	θ(°)	Wavelength (nm)	θ(°)
1540.55	90.0	1553.33	82.6
1541.35	88.2	1554.13	82.4
1542.14	87.4	1554.94	82.2
1542.93	86.8	1555.74	82.0
1543.73	86.3	1556.55	81.8
1544.52	85.9	1577.36	81.6
1545.32	85.5	1558.17	81.4
1546.16	85.1	1558.98	81.2
1446.91	84.8	1559.80	81.0
1547.71	84.5	1560.60	80.8
1548.51	84.2	1561.42	80.6
1549.31	83.9	1562.23	80.4
1550.11	83.6	1563.04	80.3
1550.91	83.4	1563.86	80.1
1551.72	83.1	1564.68	79.9
1552.52	82.9	1565.50	79.8

Referring to FIG. 2, a channel monitoring apparatus according to an embodiment of the present invention includes an input unit 200, an optical filter 210, a beam size controller 220, and a detector 230. A WDM optical signal is input to the input unit 200. In the input unit 200, a lensed fiber having a small spreading angle is used at the end portion thereof, and the WDM optical signal is controlled to be incident upon the optical filter 210 at different angles according to wavelength through a cylindrical concave lens. The optical filter 210 separates optical signals received from the input unit 200 according to their wavelengths, and output the same to the beam size controller 220.

The beam size controller 220 controls the beam size of optical signals which have passed through the optical filter 210. An optical signal adjusted by the amplifier 220 is applied to the detector 230 for converting the optical signal into an electrical signal. The optical signal converted into an electrical signal in the detector 230 is applied to a data processing device such as a microprocessor, and thus the wavelength and the OSNR of the optical signal are calculated.

Referring to FIG. 3, which is a detailed diagram of the channel monitoring apparatus shown in FIG. 2, input unit 200 of Fig 2 corresponds to optical fiber 300 and lens 310 of Fig 3 and optical filter 210 of Fig 2 corresponds to etalon 320 of Fig 3. The lens of the input unit receives WDM light through the optical fiber and outputs a plurality of optical signals each of which has a different wavelength and also has a different incident angle to the optical filter. Lens 310, for example, a cylindrical concave lens, allows a WDM optical signal received via an optical fiber 300, to be incident upon a first surface 321 of etalon 320 at various angles. Here, the lensed fiber at the end portion of the input unit collimates incident light, and then the cylindrical concave lens controls the angle of the collimated light. Now, the WDM optical signal is assumed to have been multiplexed with optical signal channels having wavelengths of λ_1 through λ_8. The optical signals incident upon the first surface 321 at different angles are positioned on a second surface 322 of the etalon 320 according to the wavelengths of the optical signal, that is, wavelengths of λ_1 through λ_8, on the basis of the incidence angles of the optical signals. This shows an application of a phenomenon in which a resonance length within the etalon 320 varies with the incidence angle θ using the principle of a Fabry-Perot resonator. The optical signals separated according to their wavelengths are input to an

infrared photo detector (IR PD) array 340. An optical instrument such as a microscope 330 may be used to adjust magnification of light in order for the IR PD to analyze the focused light. The PD array 340 receives the optical signals and converts the same into electrical signals. Data on the optical signals converted into the electrical signals by the PD array 340 is applied to a data processing device such as a microprocessor, and is used to calculate the wavelengths and the OSNR of the optical signals.

The etalon 320 can prevent different wavelengths from being detected at the same angle, only when a free spectral range (FSR) is thin enough to include channels for WDM.

The FSR with respect to the number of vibrations is given by Equation 5:

EQUATION 5

$$FSR_v = \frac{c}{2nL} \quad \cdots\cdots \quad (5)$$

wherein **c** denotes a velocity of light, **n** denotes a refractive index, v denotes the number of vibrations, and L denotes the interval between plates of etalon.

The FSR with respect to wavelength is given by Equation 6:

EQUATION 6

$$FSR_\lambda = \frac{\lambda}{2nL} \quad \cdots\cdots \quad (6)$$

wherein **c** denotes a velocity of light, **n** denotes a refractive index, λ denotes a wavelength, and L denotes the interval between plates of etalon.

The fineness representing the characteristics of light transmitted through the etalon 320 is defined by Equation 7, and must be great to increase the resolution between wavelengths.

EQUATION 7

$$fineness = \frac{FSR_\lambda}{\Delta\lambda} \quad \cdots\cdots\cdots\cdots \quad (7)$$

wherein Δλ denotes the full width half maximum of a wavelength.

Also, the fineness is a function with respect to a reflective index R as shown in Equation 8, so that it can be seen that the fineness increases with an increase in R.

EQUATION 8

$$fineness = \frac{\pi\sqrt{R}}{1-R} \quad \cdots\cdots\cdots\cdots \quad (8)$$

Calculation of the specification of the etalon 320 will be taken as an example. According to the calculation based on Equations 6, 7 and 8, a 0.8nm 32-channel optical signal, which is used for WDM optical transmission, must have a fineness in which the entire wavelength interval is 24.8nm or greater. Here, on the assumption that the refractive index **n** is 1.4 and the FSR is 30nm,

the thickness of the etalon 320 is calculated to be 28.6μm. Also, the resolution between wavelengths must be smaller than 0.1nm to be used for channel monitoring in WDM optical transmission systems, so that the fineness associated with the resolution must be increased. Here, when the FSR is set to be 30nm, the fineness must be greater than or equal to 300 to obtain a resolution of 0.1nm. Therefore, it becomes evident that the reflective index of etalon, R, must be greater than or equal to 99% to obtain a fineness of 300.

Before incident light is input to the lens 310, a lensed fiber is used to prevent the incident light from spreading. Referring to the calculated angles in Table 1, angles of incidence upon the etalon 320 must be at least 10.5° to detect wavelengths of 32 channels. Thus, the incidence angles of light are controlled by the lens 310 such as a cylindrical concave lens. Since optical signals transmitted at different angles are detected by the PD array 340, the etalon 320 must be sufficiently separated from the lens 310 so that the resolution of an optical signal is greater than or equal to 0.1nm and a sufficiently large image lands on the etalon 320. When the intensities of optical signals passed through the etalon 320 are weak, the microscope 330 is used.

The intensity of light according to wavelengths is calculated by detecting the intensity of light according to the transmitted positions using the PD array 340. At this time, the intensity of a channel having the highest intensity, and the intensity of ASE are calculated, thereby obtaining the OSNR which is the ratio of the intensity of incident optical signals to the intensity of ASE.
The distribution of light detected by the PD array 340 via the etalon 320 is calculated in terms of current. Thus, a microprocessor or the like can obtain the wavelength of each channel and the OSNR

thereof on the basis of the current value.

According to the present invention, the resonance length between two mirrors of etalon is varied according to wavelengths by making an optical signal incident upon etalon at different incidence angles according to wavelengths of the optical signal to analyze the spectrum of the optical signal. Accordingly, an optical spectrum can be obtained by detecting optical signals having different wavelengths. Therefore, an electrical device for varying the thickness of etalon is not required in the present invention, and the spectrum of an optical signal can be simply analyzed at low cost.

What is claimed is:

1. An optical filter, comprising:

an input unit for receiving a wavelength division multiplexed (WDM) optical signal via an optical transmission medium and outputting a plurality of optical signals that have different incidence angles according to the wavelengths each of said plurality of optical signals; and

a filter for receiving said plurality of optical signals from the input unit and separating the WDM optical signal into a pluraltiy of optical signals having different wavelengths using the difference between resonance lengths according to the different incidence angles.

2. The optical filter of claim 1, wherein a lens is used as the input unit.

3. The optical filter of claim 1, wherein etalon is used as the filter.

4. An optical channel monitoring apparatus, comprising:

an optical filter for receiving a wavelength division multiplexed (WDM) optical signal from an optical transmission medium, making the incidence angle of each wavelength of the WDM optical signal different from each other, and separating the WDM optical signal into a plurality of optical signals having different wavelengths using the difference between resonance lengths according to the different incidence angles; and

a detector for detecting the intensity of each of said plurality of optical signals having different wavelengths as an electrical signal.

5. An optical channel monitoring method, comprising the steps of:

receiving a wavelength division multiplexed (WDM) optical signal from an optical transmission medium and outputting a plurality of optical signals that have different incidence angles according to the wavelengths of the optical signals;

receiving said plurality of optical signals and separating the WDM optical signal into a plurality of optical signals having different wavelengths using the difference between resonance lengths according to the different incidence angles; and

detecting the intensity of each of said plurality of optical signals having different wavelengths and converting said intensity into a corresponding plurality of electrical signals.

6. The optical filter of claim 1, further comprising a detector receiving said plurality of optical signals having different wavelengths and converting them to electrical signals.

7. The optical filter of claim 6, further comprising a beam size controller to amplify said plurality of optical signals having different wavelengths in order to be detected by said detector.

8. The optical filter of claim 7, further comprising a microprocessor for determining the

wavelength and the optical signal to noise ratio of each of said plurality of optical signals having different wavelengths.

9. The apparatus of claim 4, further comprising an input unit for receiving said wavelength division multiplexed (WDM) optical signal via said optical transmission medium and outputting optical signals that have different incidence angles according to the wavelengths of the optical signals.

10. The apparatus of claim 9, further comprising an optical amplifier for allowing said plurality of optical signals having different wavelengths to be detected by said detector.

11. The apparatus of claim 4, said optical filter being a Fabry-Perot etalon.

12. The apparatus of claim 4, further comprising a microprocessor that determines the wavelength and the optical signal to noise ratio for each of said plurality of optical signals having different wavelengths from said plurality of electrical signals produced by said detector.

13. The method of claim 5, further comprising the step of inputting each of said plurality of electrical signals into a microprocessor.

14. The method of claim 13, further comprising the step of determining the wavelength and the optical signal to noise ratio of each of said plurality of optical signals having different wavelengths by processing said plurality of electrical signals by said microprocessor.

15. The method of claim 14, further comprising the step of amplifying said plurality of optical signals having different wavelengths before said plurality of optical signals impinge on said detector.

16. The method of claim 15, a Fabry-Perot etalon is used to separate said WDM signal into said plurality of optical signals having different wavelengths.

ABSTRACT OF THE DISCLOSURE

An apparatus and method for analyzing the spectrum of a wavelength division multiplexed (WDM) optical signal, in wavelength division multiplexing (WDM) optical transmission systems, are provided. An optical filter includes an input unit for receiving a wavelength division multiplexed (WDM) optical signal via an optical transmission medium and outputting optical signals that have different incidence angles according to the wavelengths of the optical signals. Also, the optical filter includes a filter for receiving the optical signals from the input unit and separating the WDM optical signal into optical signals having different wavelengths using the difference between resonance lengths according to the different incidence angles. In order to analyze the spectrum of an optical signal, the optical signal is made incident upon etalon at different incidence angles according to the wavelengths of the optical signal, and the resonance length between two mirrors of etalon is varied according to the wavelengths of the optical signal. Accordingly, an optical spectrum can be obtained by detecting optical signals having different wavelengths.

FIG. 1

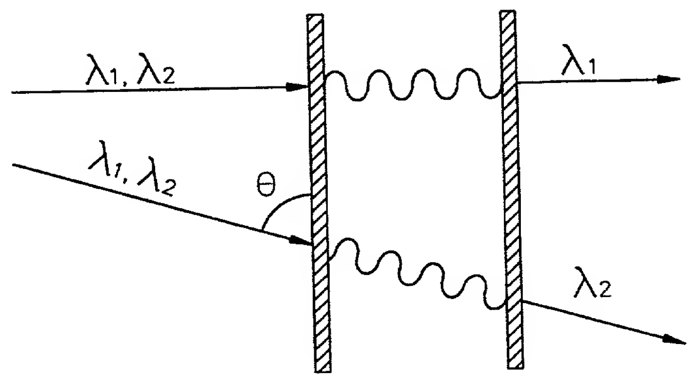


FIG. 2

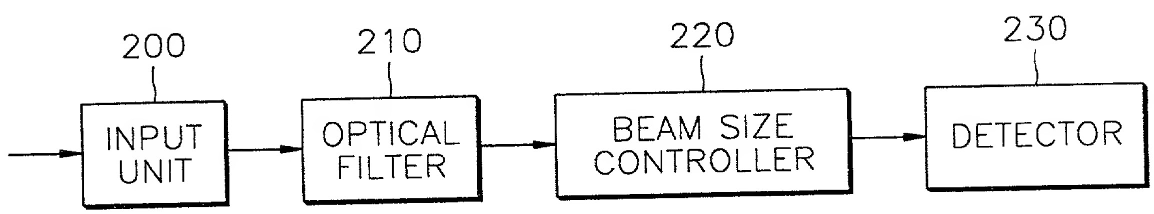
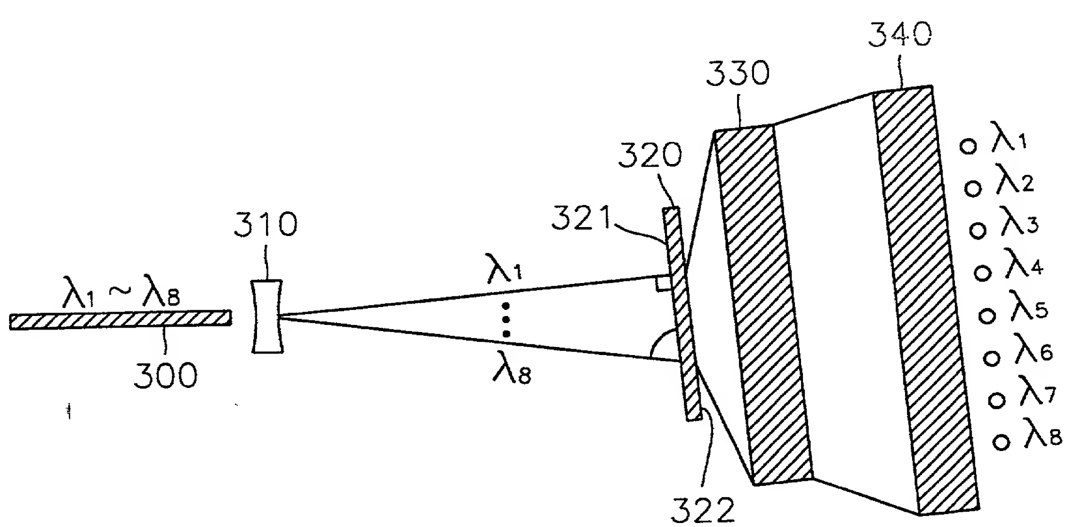


FIG. 3



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

KEUN-HO SHIN

Serial No.:	*to be assigned*	Examiner:	*to be assigned*
Filed:	18 January 2000	Art Unit:	*to be assigned*

For: OPTICAL FILTER AND APPARATUS AND METHOD FOR MONITORING OPTICAL CHANNEL USING THE OPTICAL FILTER

TRANSMITTAL OF DECLARATION

Assistant Commissioner
for Patents
Washington, D.C. 20231

Sir:

This transmittal accompanies the original Declaration for the above-referenced application.

Respectfully submitted,

Robert E. Bushnell,
Attorney for the Applicant
Registration No.: 27,774

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Folio: P55955
Date: 1/18/00
I.D.: REB/sb

PTO/[illegible] ([illegible])

DECLARATION

Docket No. [illegible]

AS A BELOW NAMED INVENTOR, I hereby declare that:
My residence, post office address and citizenship are as stated next to my name.
I believe that I am the original, first and sole [illegible] or an original, first and joint inventor [illegible], of the subject matter which is claimed and for which a patent is sought on the invention entitled

TITLE: OPTICAL FILTER AND APPARATUS AND METHOD FOR MONITORING OPTICAL CHANNEL USING THE OPTICAL FILTER

the specification of which either is attached hereto or otherwise accompanies this Declaration, or:

☐ was filed in the U.S. Patent & Trademark Office on ______ and assigned Serial No. ______

☐ and (if applicable) was amended on ______

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to patentability and to the examination of this application in accordance with Title 37 of the Code of Federal Regulations §1.56. I hereby claim foreign priority benefits under Title 35, U.S. Code §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designated at least one country other than the United States, or §119(e) of any United States provisional application(s), listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

			Priority Claimed
99-1260 (Application Number)	Korea (Country)	18 January 1999 (Day/Month/Year filed)	Yes [X] No [ ]
(Application Number)	(Country)	(Day/Month/Year filed)	Yes [ ] No [ ]
(Application Number)	(Country)	(Day/Month/Year filed)	Yes [ ] No [ ]

I hereby claim the benefit under Title 35, U.S. Code §120 of any United States application(s), or §365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application(s) in the manner provided by the first paragraph of Title 35, U.S. Code §112, I acknowledge the duty to disclose information material to patentability as defined in Title 37, The Code of Federal Regulations, §1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(STATUS patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(STATUS patented, pending, abandoned)

I hereby revoke all previously granted powers of attorney and appoint the following attorneys: Robert E. Bushnell, Reg. No. 27,774, [illegible] Reg. No. 14,971, and [illegible], Reg. No. 37,[illegible] to prosecute this application and to transact all business in the U.S. Patent & Trademark Office connected therewith and with any divisional, continuation, continuation-in-part, reissue or re-examination application, with full power of appointment and with full power to substitute an associate attorney or agent, and to receive all patents which may issue thereon, and request that all correspondence be addressed to:

Robert E. Bushnell,
Attorney-at-Law
Suite [illegible], 1522 "K" Street, N.W.
Washington, D.C. [illegible]

Payer No. [illegible]
Area Code: 202-[illegible]

I HEREBY DECLARE that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 U.S. Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

FULL NAME OF FIRST OR SOLE INVENTOR: [illegible] Citizenship: KOREA

Inventor's signature: KH [illegible] Date: 2000. 01. 1[illegible]

Residence & Post Office Address: [illegible], Republic of Korea

FULL NAME OF SECOND JOINT INVENTOR: ______ Citizenship: ______

Inventor's signature: ______ Date: ______

Residence & Post Office Address:

FULL NAME OF THIRD JOINT INVENTOR: ______ Citizenship: ______

Inventor's signature: ______ Date: ______

Residence & Post Office Address:

FULL NAME OF FOURTH JOINT INVENTOR: ______ Citizenship: ______

Inventor's signature: ______ Date: ______

PTO/SB/01 (6/95)

DECLARATION

Docket No. P55955

AS A BELOW NAMED INVENTOR, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name.

I believe that I am the original, first and sole (if only one name is listed below), or an original, first and joint inventor (if plural names are listed below), of the subject matter which is claimed and for which a patent is sought on the invention entitled:

TITLE: OPTICAL FILTER AND APPARATUS AND METHOD FOR MONITORING OPTICAL CHANNEL USING THE OPTICAL FILTER

the specification of which either is attached hereto or otherwise accompanies this Declaration, or:

☐ was filed in the U.S. Patent & Trademark Office on ____________ and assigned Serial No. ____________,

☐ and (if applicable) was amended on ____________.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to patentability and to the examination of this application in accordance with Title 37 of the Code of Federal Regulations §1.56. I hereby claim foreign priority benefits under Title 35, U.S. Code §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT International application which designated at least one country other than the United States, or §119(e) of any United States provisional application(s), listed below and have also identified below any foreign applications for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

(Application Number)	(Country)	(Day/Month/Year filed)	Priority Claimed:
99-1260	Korea	18 January 1999	Yes [X] No [ ]
			Yes [ ] No [ ]
			Yes [ ] No [ ]

I hereby claim the benefit under Title 35, U.S. Code, §120, of any United States application(s), or §365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application(s) in the manner provided by the first paragraph of Title 35, U.S. Code, §112, I acknowledge the duty to disclose information material to patentability as defined in Title 37, The Code of Federal Regulations, §1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(STATUS: patented, pending, abandoned)

I hereby revoke all previously granted powers of attorney and appoint the following attorneys: Robert E. Bushnell, Reg. No. 27,774, Michael D. Parker, Reg. No. 34,973, and Darren R. Crew, Reg. No. 37,806 to prosecute this application and to transact all business in the U.S. Patent & Trademark Office connected therewith and with any divisional, continuation, continuation-in-part, reissue or re-examination application, with full power of appointment and with full power to substitute an associate attorney or agent, and to receive all patents which may issue thereon, and request that all correspondence be addressed to:

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I HEREBY DECLARE that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 U.S. Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Inventor's signature: ____________ Date: ____________